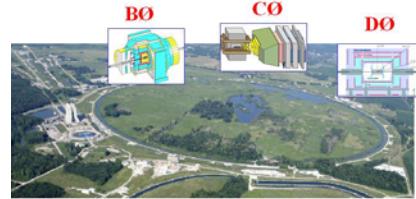




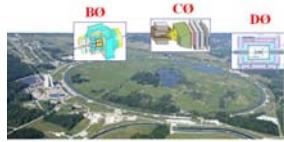
btev



QCD Physics with BTeV



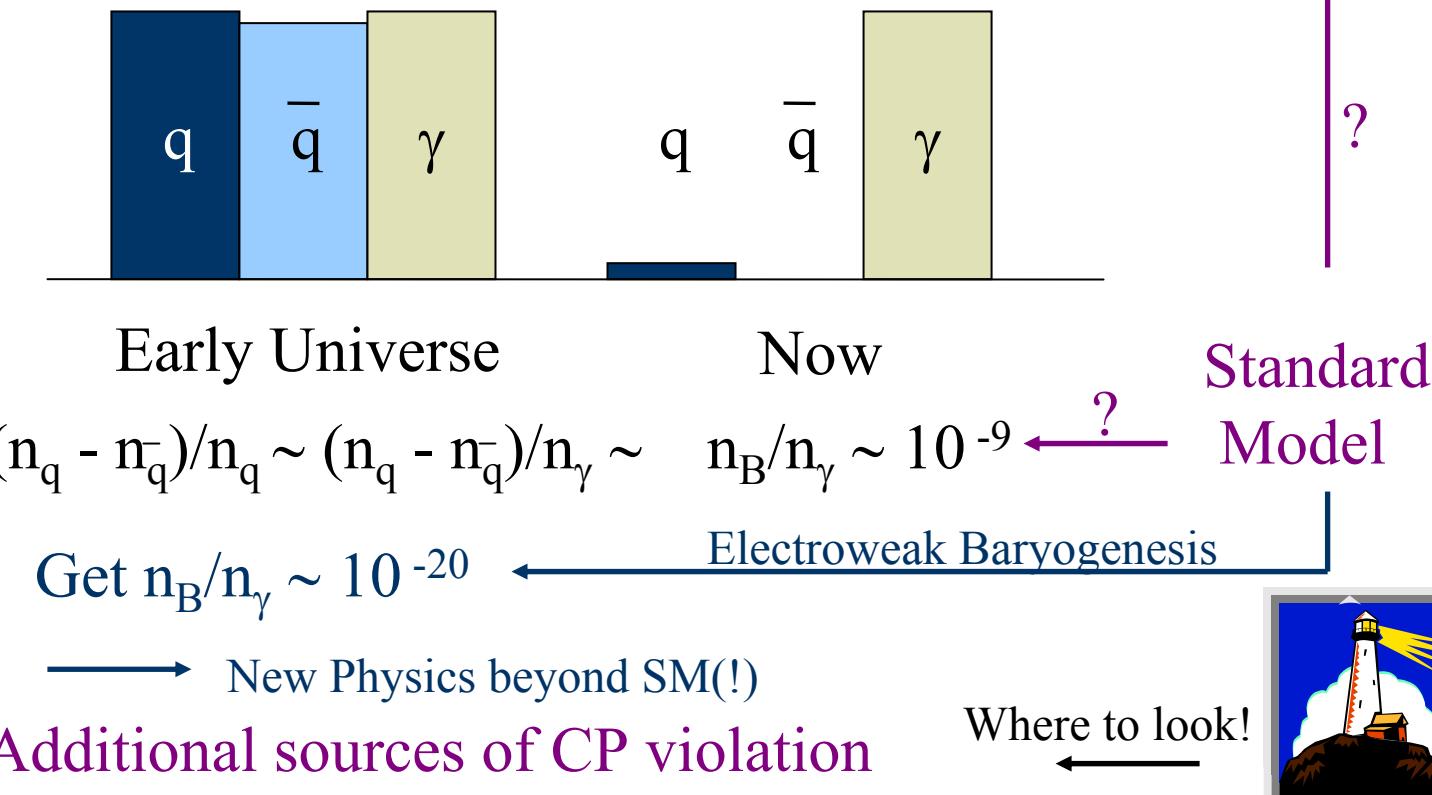
- The main physics motivation for BTeV
 - CP Violation using b & c decays
 - Physics Beyond the Standard Model
- Detector description
- Expectations for QCD studies at BTeV

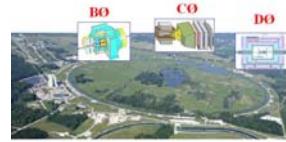


CP Violation: A Fertile Frontier

How did we become a matter (dominated) universe?

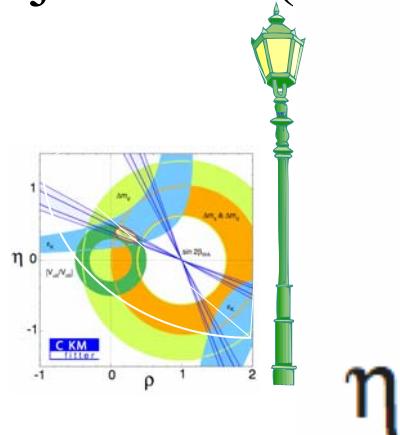
Andrei Sakharov's conditions (1967):



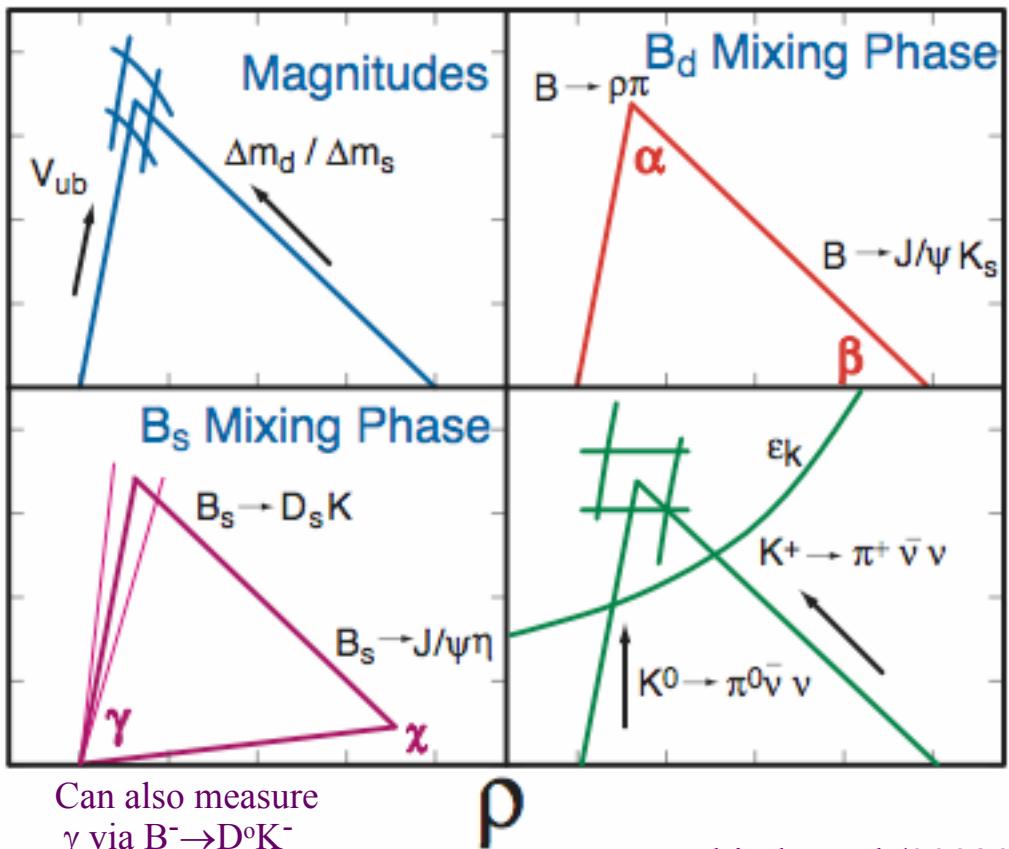


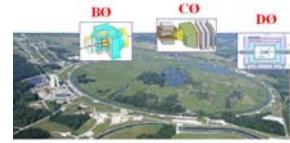
Measurements of the CKM Matrix

Don't just look (measure) under one lamp post!



- Compare to the comprehensive tests of EW: repeat for quark flavour physics!

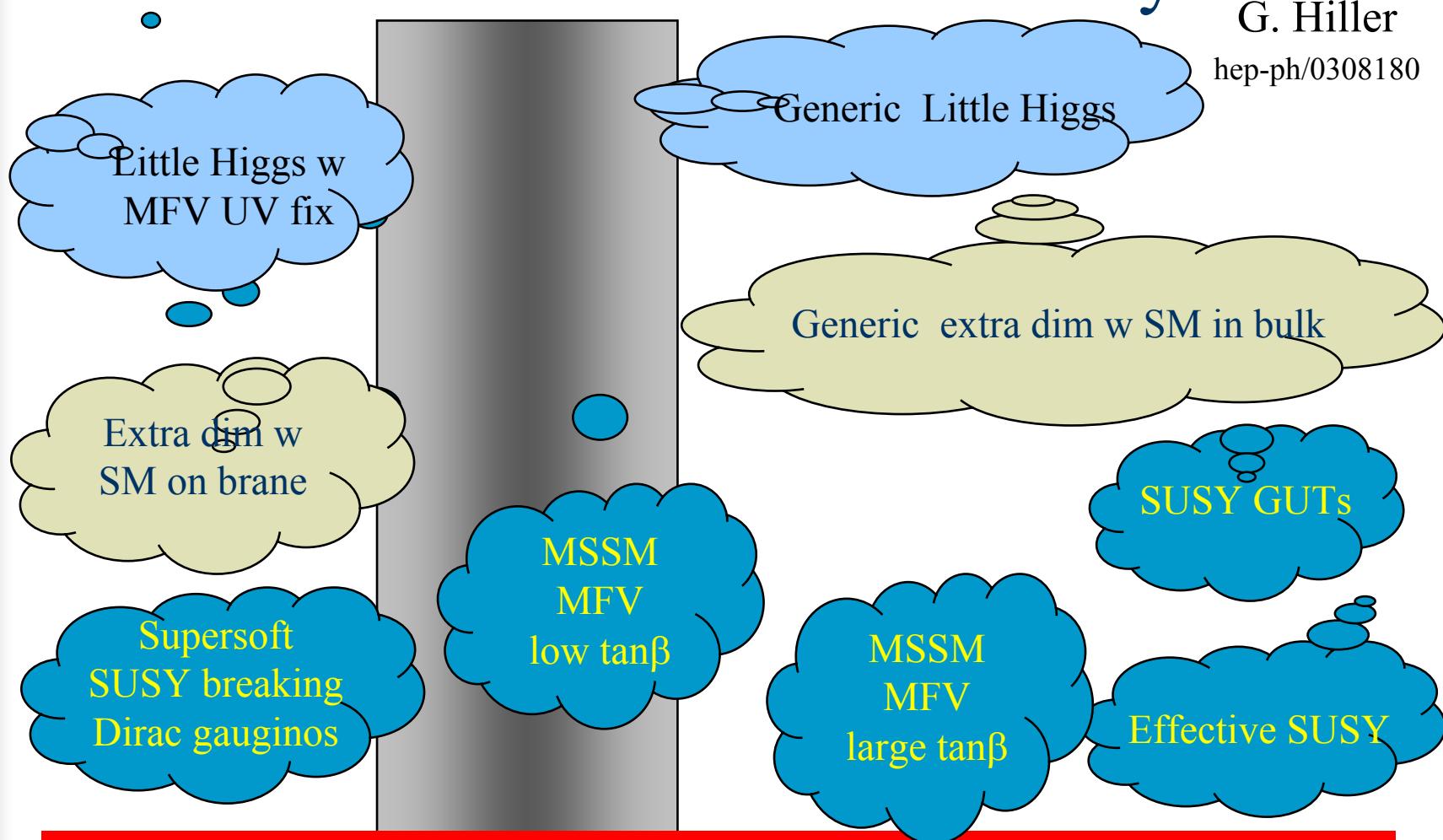




Flavour Violation in Models which address the Hierarchy

G. Hiller

hep-ph/0308180



SM-like B physics

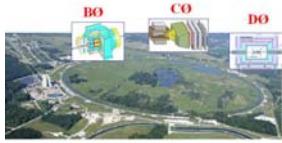
New Physics in B data

Harry W. K. Cheung

Workshop on the Future of QCD at the
Tevatron, May 22, 2004

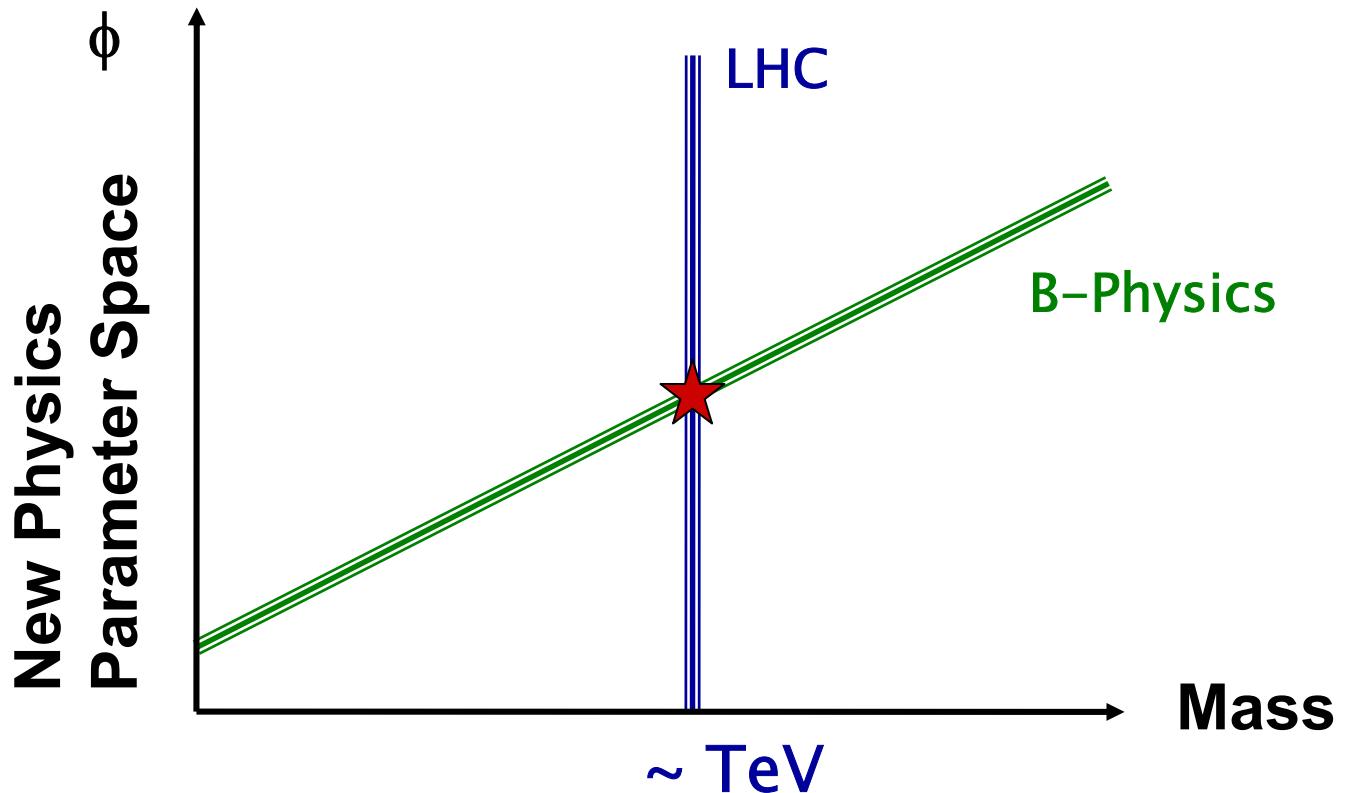
vevtev

4

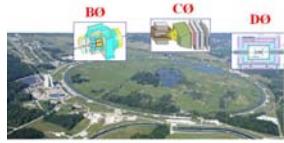


Physics Beyond the SM: LHC?

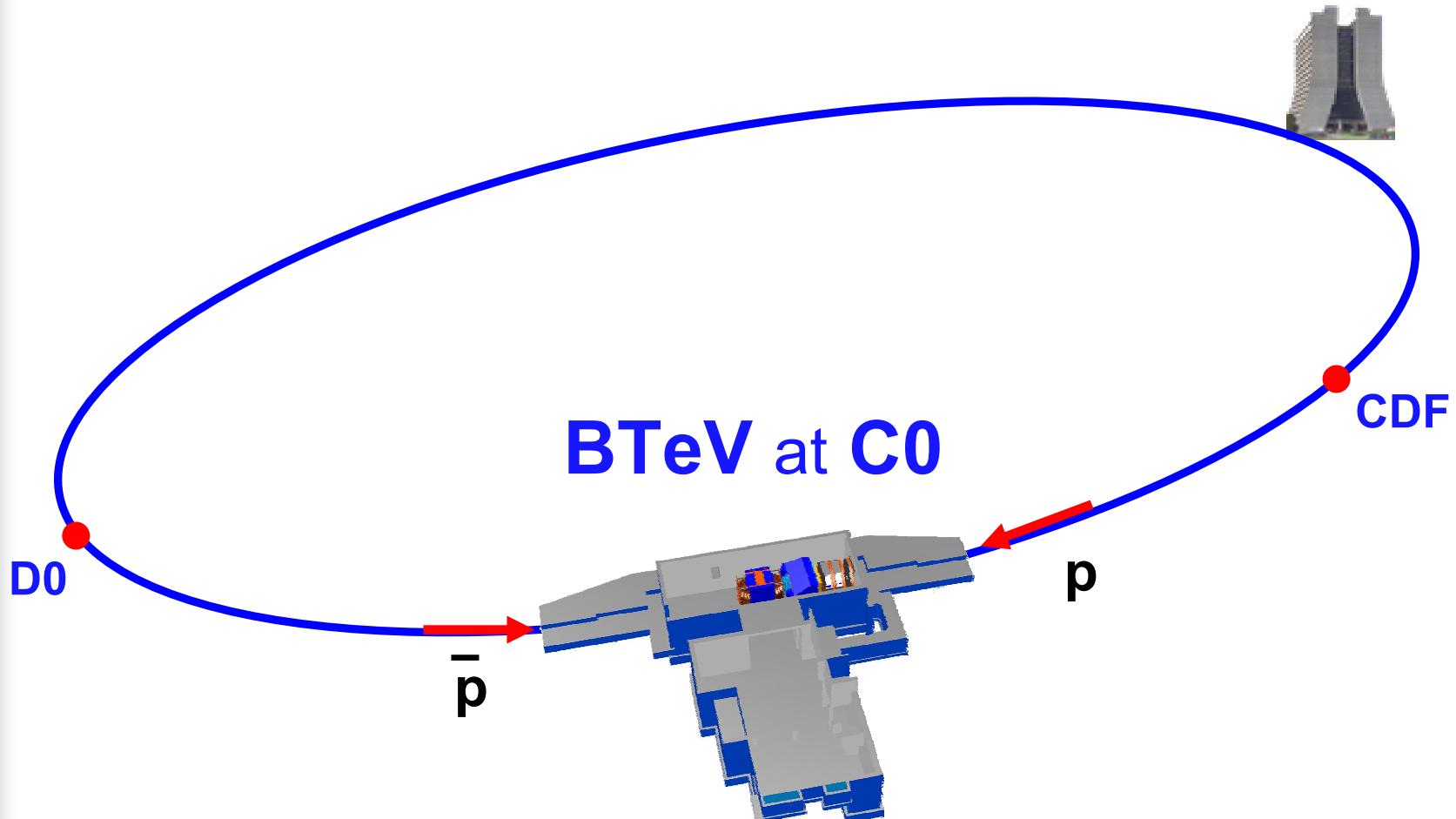
Pictorial Example from Hewett (WIN03):

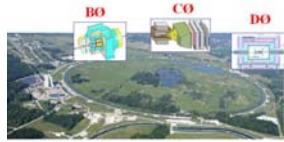


Complementary knowledge from LHC and B Decays!



BTeV at the Fermilab Tevatron





BTeV Collaboration

Origins: ■ Fnal FT ■ CLEO ■ Hera/HeraB

Belarussian State: D.Drobychev,
A.Lobko, A.Lopatrik, R.Zouversky

UC Davis: P.Yager

Univ. of Colorado:

J.Cumalat, P.Rankin, K.Stenson

Fermilab: J.Appel, E.Barsotti,
C.N.Brown, J.Butler, H.Cheung,
D.Christian, S.Cihangir, M.Fishler,
I.Gaines, P.Garbincius, L.Garren,
E.Gottschalk, A.Hahn, G.Jackson,
P.A.Kasper, P.H.Kasper, R.Kutschke,
S.Kwan, P.Lebrun, P.McBride,
J.Slaughter, M.Votava, M.Wang, J.Yarba

Univ. of Florida: P.Avery

University of Houston: A.Daniel,
K.Lau, M.Ispiryan, B.W.Mayes,
V.Rodriguez, S.Subramania, G.Xu

Illinois Institute of Technology:
R.A.Burnstein, D.Kaplan, L.M.Lederman,
H.A.Rubin, C.White

Univ. of Illinois: M.Haney, D.Kim,
M.Selen, V.Simaitis, J.Wiss

Harry W. K. Cheung

INFN - Frascati:

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M.Caponero, F.Fabbri, F.Felli,
M.Giardoni, A.La Monaca,
E.Pace, M.Pallotta, A.Paoletti

INFN - Milano: G.Alimonti,
M.Dinardo, L.Edera, S.Erba,
D.Lunesu, S.Magni, D.Menasce,
L.Moroni, D.Pedrini, S.Sala,
L.Uplegger

INFN - Pavia: G.Boca,
G.Cossali, G.Liguori, F.Manfredi,
M.Manghisoni, M.Marengo, L.Ratti,
V.Re, M.Santini, V.Speciale,
P.Torre, G.Traversi

IHEP Protvino, Russia:

A.Derevchikov, Y.Goncharenko,
V.Khodyrev, V.Kravtsov,
A.Meschanin, V.Mochalov,
D.Morozov, L.Nogach, P.Semenov,
K.Shestermanov, L.Soloviev,
A.Uzunian, A.N.Vasiliev

Univ. of Insubria in Como:

P.Ratcliffe, M.Rovere

University of Iowa:

C.Newsom, & R.Brauner

Workshop on the Future of QCD at the
Tevatron, May 22, 2004

University of Minnesota:

J.Hietala, Y.Kubota, B.Lang,
R.Poling, A.Smith

Nanjing Univ. (China):

T.Y.Chen, D.Gao, S.Du, M.Qi,
B.P.Zhang, Z.Xi Zhang, J.W.Zhao

New Mexico State Univ.:

V.Papavassiliou

Northwestern University:

J.Rosen

Ohio State University:

K.Honscheid, & H.Kagan

Univ. of Pennsylvania:

W.Selove

Univ. of Puerto Rico:

A.Lopez, H.Mendez, J.E.Ramirez
W.Xiong

**Univ. of Science & Tech. of
China:** G.Datao, L.Hao, Ge Jin,
T.Yang, & X.Q.Yu

Shandong Univ. (China):

C.F.Feng, Yu Fu, Mao He, J.Y.Li,
L.Xue, N.Zhang, & X.Y.Zhang

Southern Methodist Univ.:

T.Cowan, M.Hosack

Syracuse University:

M.Artuso, S.Blusk, J.Butt,
C.Boulahouache,
O.Dorjkhaidav, J.Haynes,
N.Menaa,

R.Mountain, M.Muramatsu,
R.Nandakumar, L.Redjimi, R.Sia,
T.Skwarnicki, S.Stone, J.C.Wang,
K.Zhang

Univ. of Tennessee:

T.Handler, R.Mitchell

Vanderbilt University:

W.Johns, P.Sheldon,
E.Vaandering, M.Webster

Univ. of Virginia:

M.Arenton, S.Conetti, B.Cox,
A.Ledovskoy, H.Powell,
M.Ronquest, D.Smith,
B.Stephens, Z.Zhe

Wayne State University:

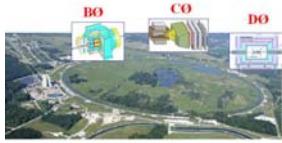
G.Bonvicini, D.Cinabro,
A.Shreiner

University of Wisconsin:

M.Sheaff

York University: S.Menary

bTeV

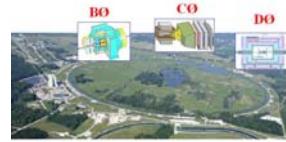


Why do b and c Physics at Tevatron?

- Large samples of b quarks
 - Get $\sim 4 \times 10^{11}$ b hadrons per 10^7 s at $L = 2 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$
 - $e^+e^- \Upsilon(4S)$ get 2×10^8 B hadrons per 10^7 s at $10^{34} \text{ cm}^{-2}\text{s}^{-1}$
- B_s , Λ_b and other b-flavored hadrons are accessible for study at the Tevatron
- Charm rates are $\sim 10\times$ larger than b rates

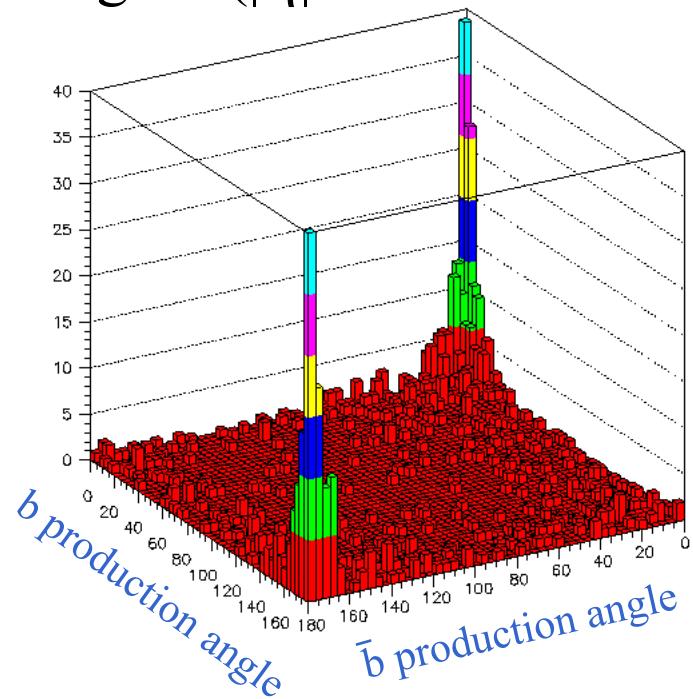
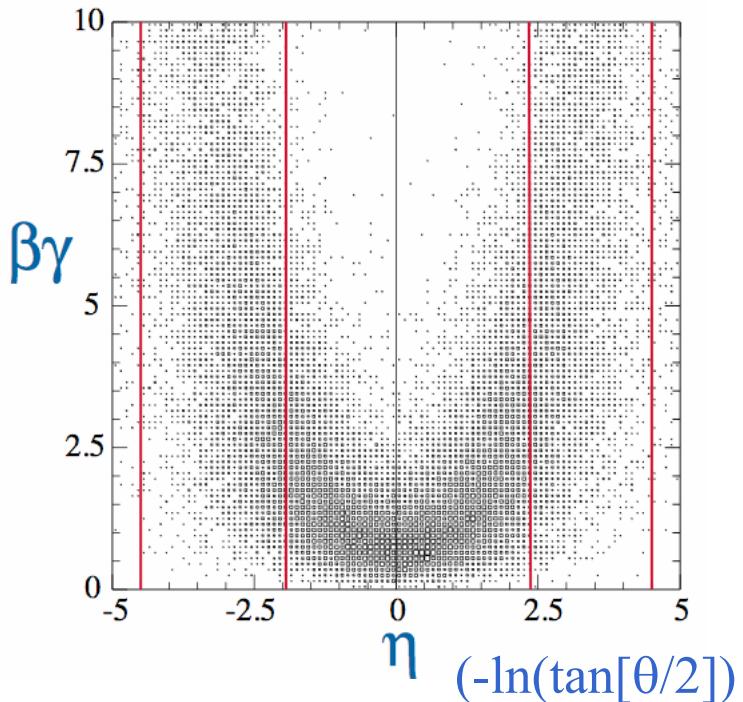
Some assumed parameters for the Tevatron for simulations:

- CMS energy = 2 TeV and $L = 2 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$
- Time/crossing = 396 ns
- Interaction region $\sigma_z = 30\text{cm}$ and $\sigma_{x,y} = 50\mu\text{m}$
- $\bar{b}b$ cross section = 100 μb



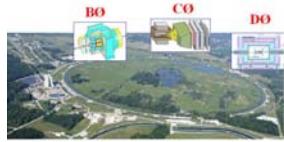
Why look in the Forward Region?

BTeV detects in the forward region ($|\eta|$ from 1.9 to 4.5)

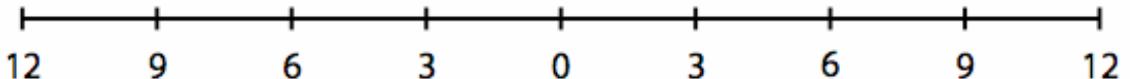


- Better decay length separation
- Less multiple scattering

- More $B\bar{B}$ in the Detector
- Better away side tagging

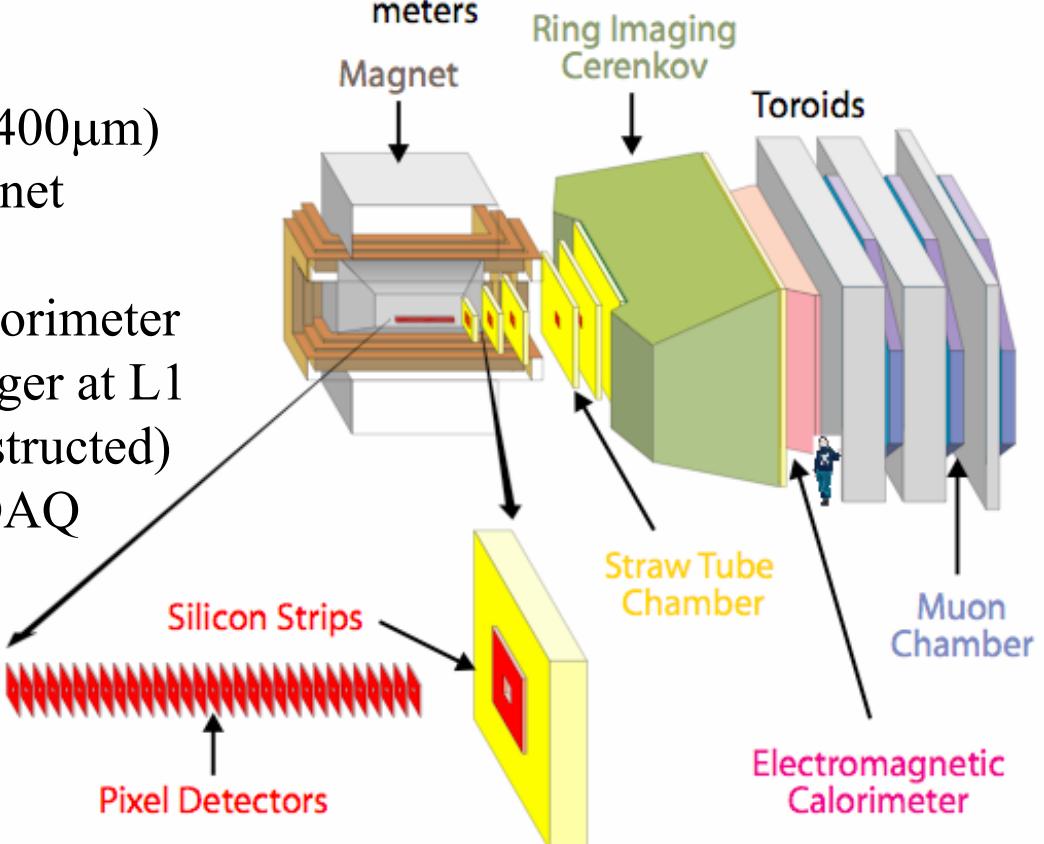


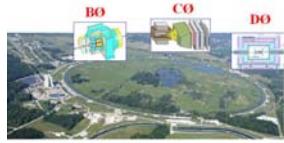
The BTeV Detector



Main/Unique Features

- Vertex pixel ($50\mu\text{m} \times 400\mu\text{m}$) detector in dipole magnet
- RICH for particle ID
- PbWO_4 crystal EM calorimeter
- Vertex separation Trigger at L1 (primary vertex reconstructed)
- Powerful high speed DAQ (output up to 4KHz)

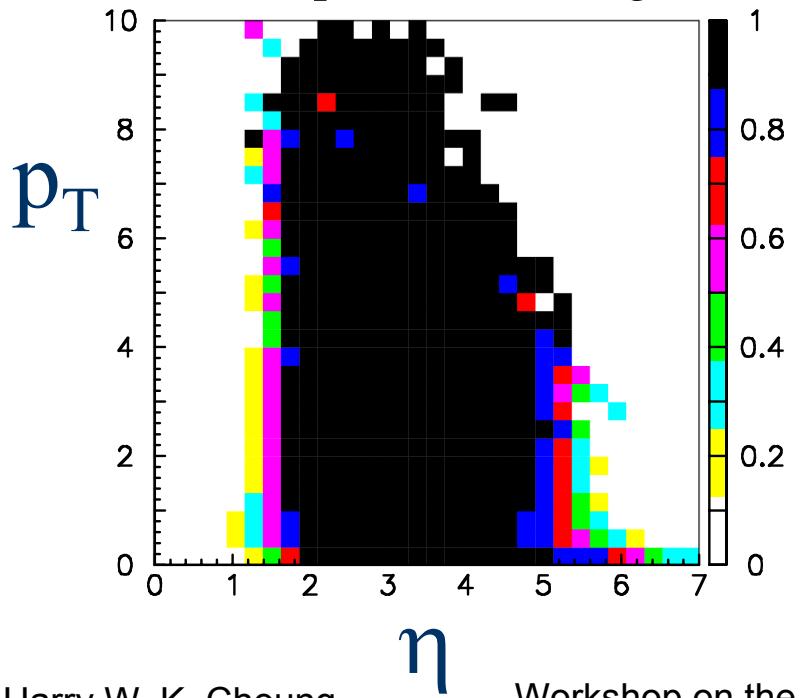




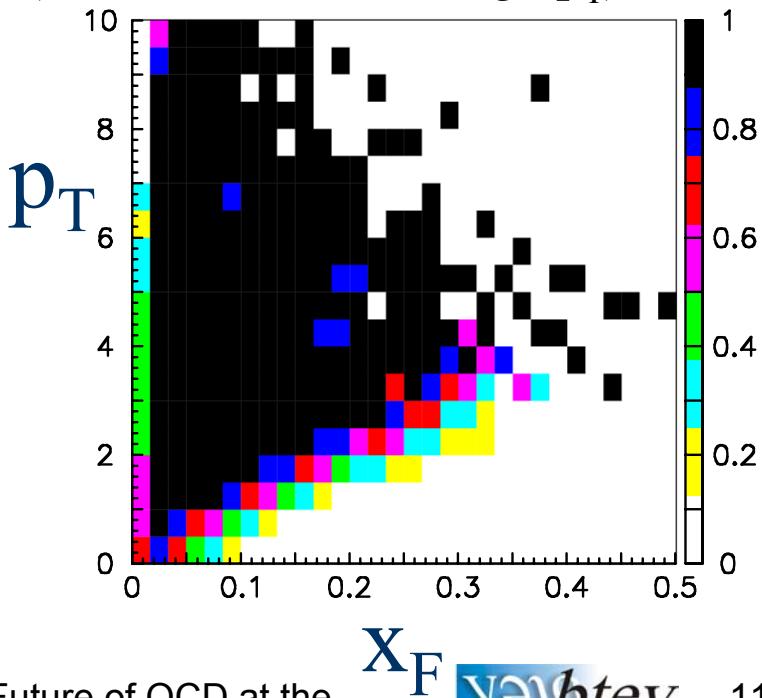
Implications for QCD Physics

- Important BTeV detector features:
 - Excellent tracking 10 - 300 mrad ($\eta \sim 1.9 - 5.3$) for single tracks
 - ◊ Good (flat) acceptance down to small angles and small p_T

Acceptances for single tracks (lack of statistics at high p_T):



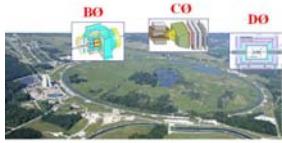
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Tevatron, May 22, 2004

vbftev

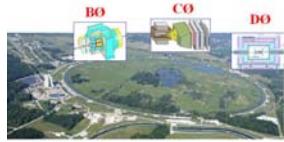
11



Implications for QCD Physics

- Important BTeV detector features:

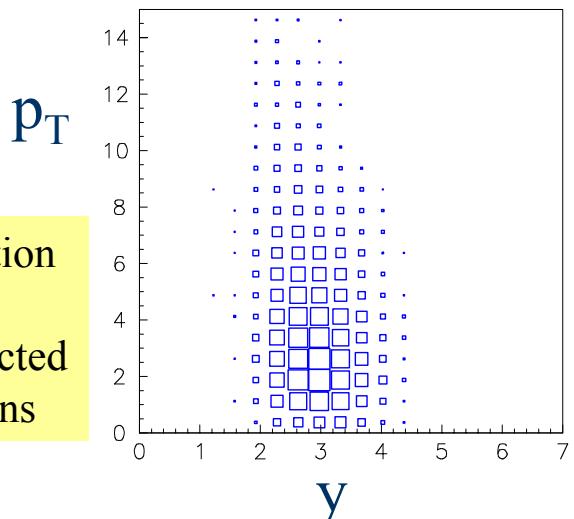
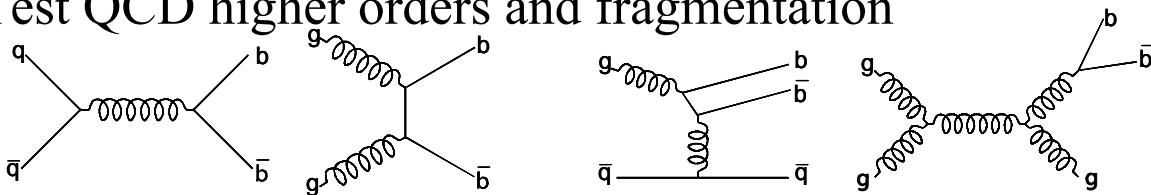
- Excellent tracking 10 - 300 mrad ($\eta \sim 1.9 - 5.3$)
 - ◊ Good acceptance down to small angles
 - ◊ Good acceptance for low p_T tracks
- EM PbWO₄ crystal calorimeter ($25\lambda_0$ and $1\lambda_I$)
 - ◊ Excellent (multiple) photon detection and resolution
- No Hadronic calorimeter, no 4π coverage
 - ◊ No jet studies? (jets with poor energy resolution)
 - ◊ No missing E_T measurement, No rapidity-gap detection
- Trigger on displaced tracks/vertices or muons only
 - ◊ Excellent heavy quark production and decay studies
 - ◊ No trigger for e.g. direct photon studies, diffractive, jets



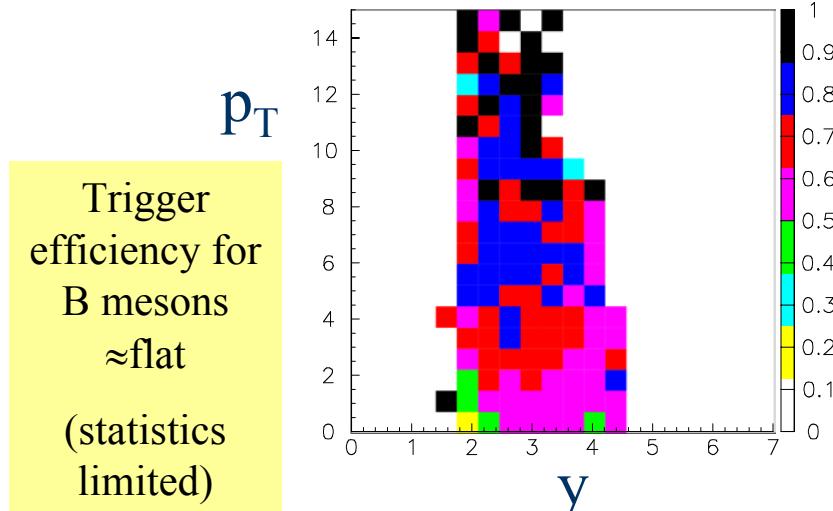
QCD Physics at BTeV

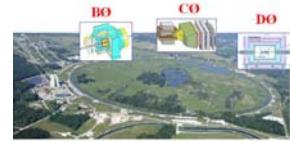
Heavy quark production in the forward region:

- Study region of (p_T, y) complementary to CDF, D0 central detectors
- Test QCD higher orders and fragmentation



Trigger efficiency for B mesons ≈ flat
(statistics limited)



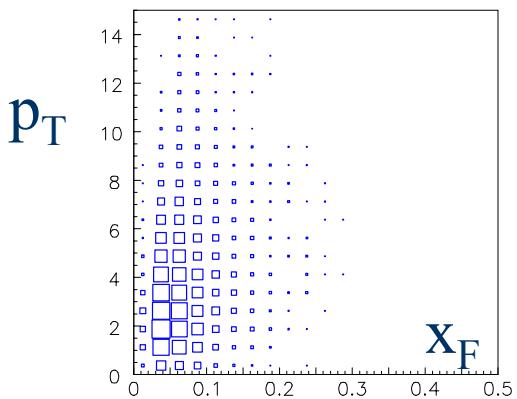


QCD Physics at BTeV

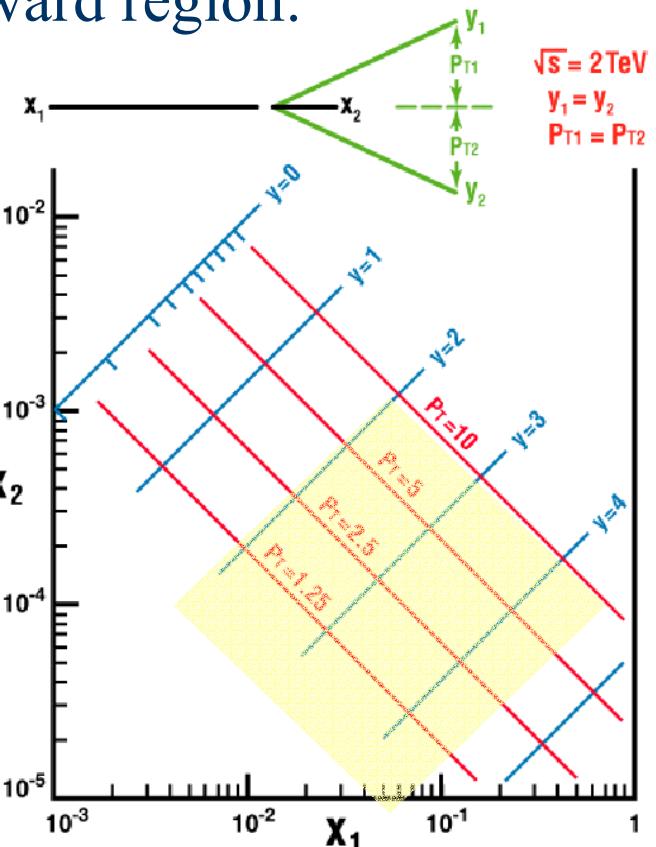
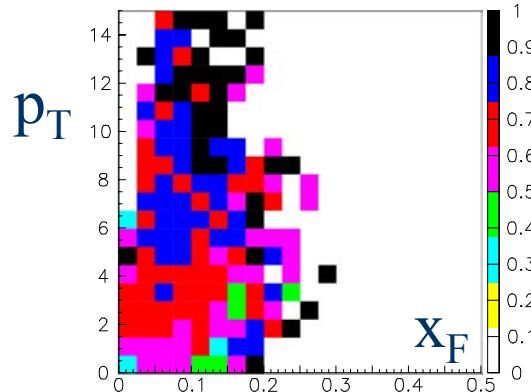
Heavy quark production in the forward region:

- Probe PDF's at low and high x_{Bj}

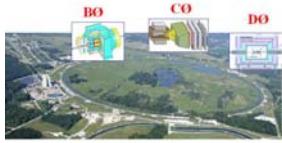
Distribution
of
reconstructed
B mesons



Trigger
efficiency for
B mesons
 \approx flat
(statistics
limited)



From M.Albrow, "GTEV", DESY, Mar. 2004



QCD Physics at BTeV

Heavy quark production - $b\bar{b}$ correlations ($\Delta\phi, \Delta y, \Delta p_T, \dots$)

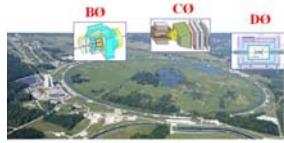
- Sensitive to higher order QCD contributions & low x in PDF(?)
- Less model dependence in QCD predictions(?)

Our studies concentrated on rare decays and tagging, but...

- Estimate $\sim 10^7$ fully reconstructed B mesons (in 2 fb^{-1})
- $\sim 10^6$ fully recon. B + opposite tagged \overline{B} (not a jet)
- $\sim 10^3$ fully recon. BB + B \overline{B} (c.f. 10^5 - 10^6 di-b-jets CDF/D0)
- $\sim 10^4$ - 10^5 fully reconstructed D \overline{D} (depends on trigger)

Could also look at bb or $\bar{b}\bar{b}$ events (besides from B mixing)

- E.g. due to gluon splitting in fragmentation
- SUSY $\tilde{g} \rightarrow b\tilde{b}$ (~c.f. done at Run I and Run II?)



QCD Physics at BTeV

Drell-Yan processes as probes of PDF (not direct photon)

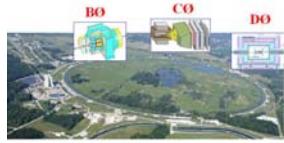
- Possible to trigger, but backgrounds unknown at low dilepton mass

Production of J/ψ and Υ in the forward region

- Useful in discriminating NRQCD vs CEM, colour-singlet vs octet?
- Can reconstruct excited states of $c\bar{c}$ and $b\bar{b}$ (different J^P) using γ 's

Heavy quark spectroscopy (excellent γ det. and particle ID)

- B_c spectroscopy and decays, $\sim 10^4$ fully reconstructed ($\sim 10^3$ Run II)
- Spectroscopy of other b and c hadrons (many excited states)
- Light quark spectroscopy via B and D meson decays



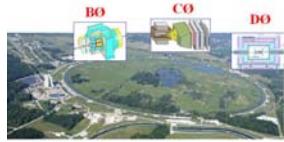
QCD Physics at BTeV

Search/measure more exotic quark states

- Must be able to trigger on these states (lifetime or muons in decay)
- qqQ and qQQ and even QQQ baryons
- pentaquarks and tetraquarks with b and c quarks

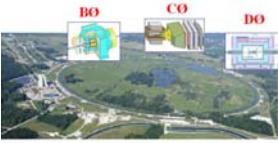
More QCD Physics at BTeV?

- Besides concerns of uncertainties in extracting CP-violating/CKM measurements in B decays, not much focus on possible QCD physics
- Not trying to sell QCD physics at BTeV, but this is an excellent opportunity to see what could be measured at BTeV and get collaborators who might want to do this type of physics



Summary

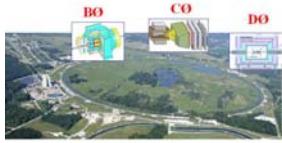
- BTeV is a proposed experiment to study CP violation, rare and forbidden b & c decays in the forward region
- Goal for BTeV is to discover New Physics, or help interpret New Physics found elsewhere, using b & c decays; &
- Measure Standard Model “fundamental constants”
- Although QCD physics has not been a focus for BTeV there will be many interesting areas of study due to detection in the forward region, excellent photon detection & particle ID, and excellent efficiency for b & c hadron reconstruction
- This is an excellent opportunity to see if BTeV can do the type of QCD physics you are interested in.



Proceed to Backup Slides

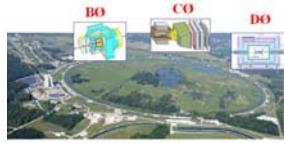
Harry W. K. Cheung

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Tevatron, May 22, 2004



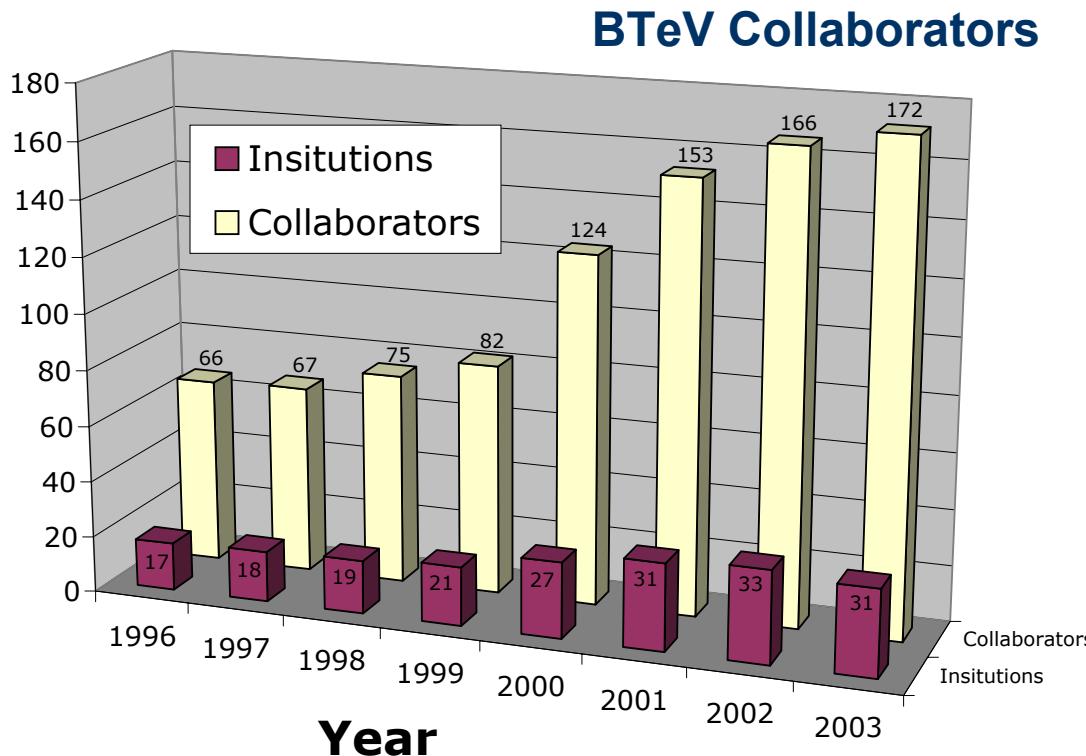
Brief History and Status of BTeV

- May 1997 - EOI, 161 pages
- Dec. 1997 - Addendum, 62 pages - address PAC concerns
⇒ BTeV becomes a R&D project
- May 1999 - Preliminary TDR, 373 pages (full BTeV)
- May 2000 - Proposal, 429 pages, submitted to Fermilab
June 2000 ⇒ PAC unanimously recommends Stage 1 approval
⇒ Approval from Director (2-arm)
- Mar. 2002 - Proposal update, 126 pages (request from Lab, 1-arm)
⇒ PAC unanimously recommends approval of descoped BTeV
⇒ Approval from Director (1-arm)
- Oct. 2002 - Fermilab conducts cost review of BTeV (Temple)
- Mar. 2003 - Review of BTeV by P5
⇒ Oct. 2003 - P5 supports building BTeV and recommends earliest construction
- Mar. 2004 - Temple review of BTeV cost range and schedule range
.....



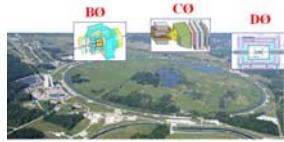
Continual and Growing interest in BTeV

- Despite long review and approval process and problems for universities getting funding (e.g. for R&D):



Most of these
are senior
members -
expect to
grow to 300.

- There is very strong interest in the physics and technology of BTeV



Schedule

- If we get DOE approval and funding:

Year		2003	2004	2005	2006	2007
Tevatron Collider						BTeV
		CDF & DZero	CDF & DZero	CDF & DZero	CDF & Dzero	CDF & Dzero
Neutrino Program	B	MiniBoone	MiniBoNE	MiniB	OPEN	OPEN
	MI			MINOS	MINOS	MINOS
Meson 120	MT	Test Beam	Test Beam	Test Beam	Test Beam	Test Beam
	MC	E907/MIPP	E907/MIPP	E907/MIPP	OPEN	OPEN
Year		2008	2009	2010	2011	2012
Tevatron Collider		BTeV	BTeV	BTeV	BTeV	BTeV
		CDF & DZero	CDF & DZero	OPEN	OPEN	OPEN
Neutrino Program	B	OPEN	OPEN	OPEN	OPEN	OPEN
	MI	MINOS	MINOS	OPEN	OPEN	OPEN
Meson 120	MT	Test Beam	Test Beam	Test Beam	Test Beam	Test Beam
	MC	E906	E906-DrellYan	E906-DrellYan	E906-DrellYan	OPEN
	ME/P	OPEN	CKM	CKM	CKM	CKM OPEN

We are very excited about BTeV and eager to get construction funded and started!

We welcome new collaborators!